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SAGEN USER'S GUIDE
Version 1.5

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IDA Paper P-2028 documents a tool that can facilitate the description of processes for the Strategic Defense System (SDS) and Battle Management/Command, Control and Communications (BM/C3) architectures. The process descriptions generated by this tool conform to the Strategic Defense Initiative (SDI) Architecture Dataflow Modeling Technique (SADMT)

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1. INTRODUCTION

This paper documents the use of a tool that can facilitate the description of processes for Strategic Defense System (SDS) and Battle Management/Command, Control and Communications (BM/C3) architectures. The generated process description conforms to the Strategic Defense Initiative (SDI) Architecture Dataflow Modeling Technique (SADMT). SADMT descriptions use a complex Ada template to simulate SDS and BM/C3 architectures. This tool, called SAGEN (for SADMT Generator), accepts a simpler specification of the architecture and automatically generates the required SADMT template.

SAGEN eliminates much of the drudgery of specifying the SADMT template for each module. However, Ada must still be used to specify port linkages and process semantics. SADMT modules generated by SAGEN may then be compiled by an Ada compiler, linked with the SADMT Simulation Framework [Linn 88] which is also written in Ada, and executed to simulate the performance of the system.

The SAGEN specification provides constructs to support the SADMT process model. A system is modeled as a hierarchy of processes which communicate via ports. Familiarity with this abstract model as described in [Linn 88] is assumed, but familiarity with the syntax and implementation details of SADMT is not required.

This paper is organized as follows:

Section 2	SADMT process model
Section 3	notational, syntactic, and semantic conventions
Section 4	SAGEN syntax
Section 5	SAGEN semantics
Section 6	execution of SAGEN
Section 7	references
Appendix A	SAGEN example
Appendix B	generated SADMT code
Appendix C	Simulation output

2. PROCESS MODEL

To capture SDS and BM/C3 architectural specifications in early design stages, SADMT defines an abstract entity called a "process" and a mechanism for specifying a process as a set of communicating subprocesses. SADMT processes are defined in a specific format and interprocess communications are performed according to a specific model. SADMT architectural descriptions use the standard syntax and semantics of Ada to capture the information needed to simulate the system.

In SADMT, a system is viewed as a hierarchy of processes. The system itself is the zero-th level process and is specified as a network of level-one processes; similarly, a level-n process may be specified as an interconnected set of level-(n+1) processes. Eventually, some processes will be leaf nodes since they are not decomposed further. The leaf processes contain the semantics of

the system. Leaf processes need not all be at the same level.

SADMT processes are defined to have "ports", i.e., windows for passing data into or out of a process. All interprocess communication is accomplished via these ports. A port is either an input port or an output port; SADMT makes no provision for bi-directional ports. Furthermore, ports in SADMT are typed to restrict the data which may flow into or out of a port.

SADMT provides a facility to specify the interconnections of communicating processes. There are three types of interprocess communications links: (1) internal, (2) input-inherited, and (3) output-inherited. In all cases, the data type of the connected ports must be the same. The first type of link, internal, connects an output port of a subprocess to an input port of another subprocess of the same parent process. Inherited links capture the concept that data flowing through a port on a higher level process is actually the input or output of lower level processes. An input-inherited link connects an input port on a parent process to an input port one of its child subprocesses. An output-inherited link connects an output port on a child subprocess to an output port on its parent process.

Various types of links are depicted in Figure 1. The highest level of a BM/C3 process is shown with a single input port and a single output port. (Note that port names and types are not indicated.) Figure 2 is an exploded view of the BM/C3 process, seen as an interconnected set of three subprocesses: (1) threat assessment, (2) weapon assignment, and (3) view of world (a process to manage retained state data.) The solid lines represent internal links, while the dashed lines represent inherited links.
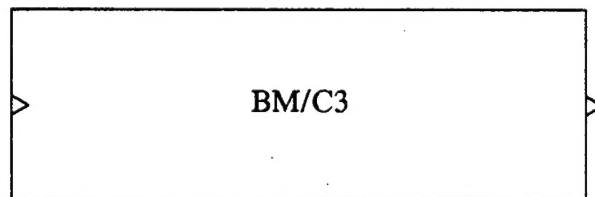
Figure 1. Depiction of a BM/C3 Process

SADMT processes are simulated within the SADMT Simulation Framework [Linn 88]. The Simulation Framework simulates the physical environment in which the SDS operates. The Simulation Framework employs two primitives - platforms and cones. Platforms represent all physical entities including the sensors, weapons, and carrier vehicles of the SDS and the weapons and debris of the threat. Cones represent entities such as communication waves and laser beams.

Platform. are composed of logical processes and technology modules (see Figure 3). Technology modules represent hardware technology such as sensors, weapons, communications and boosters. Technology modules provide the interface between SADMT processes and the Simulation Framework.
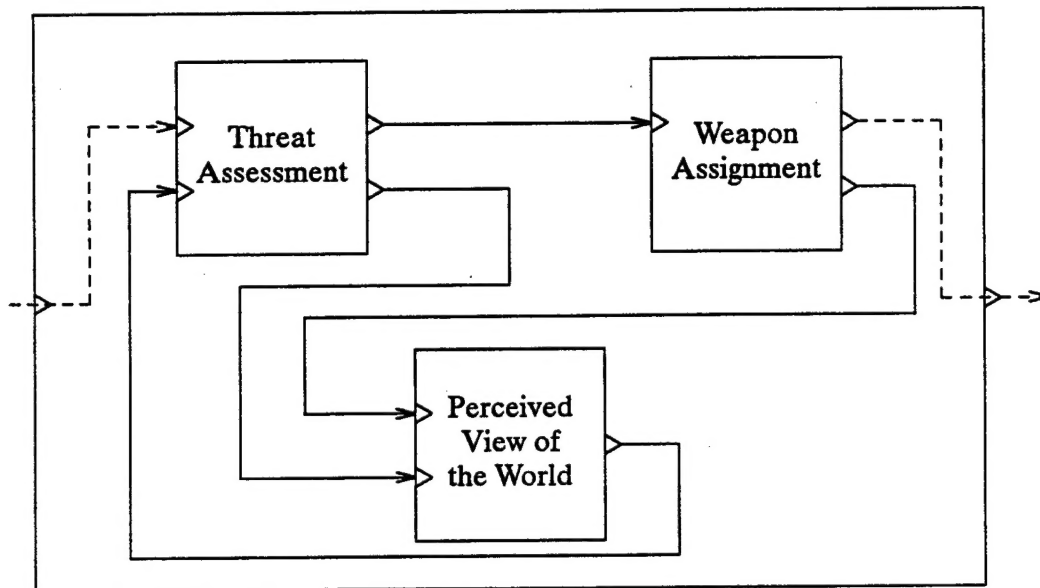
Figure 2. Exploded View of BM/C3

3. CONVENTIONS

3.1 Notational Conventions

The following notational conventions are used in the syntactic specification of SAGEN:

<item>	a variable item
[item]	an optional item
{item1 | item2}	item1 or item2
{items}*	items repeated zero or more times

The variables in the syntactic specification are defined as follows:

<alias>	a string of characters
<data_type>	a valid Ada data type
<declarations>	valid Ada declarations
<default>	a valid Ada expression
<discriminant>	a valid Ada discriminant
<name>	a valid Ada identifier
<param_list>	a list of parameters separated by commas
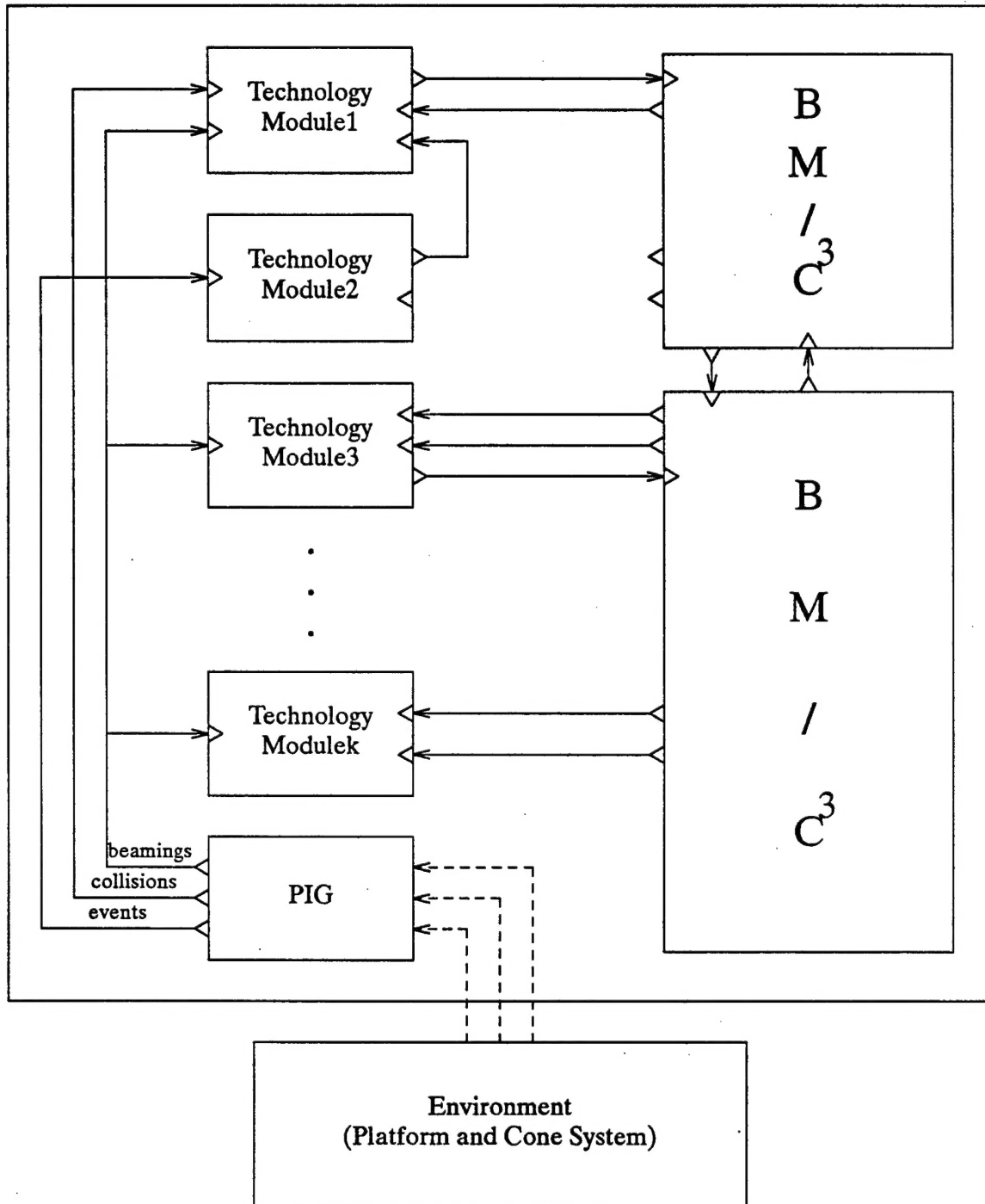
Figure 3. Platforms, Technology Modules and Processes

<range>	a valid Ada integer range
<with_or_use>	a set of valid Ada context and/or visibility clauses

3.2 Syntactic Conventions

SAGEN syntactic conventions are Ada-like and non-restrictive:

1. A SAGEN statement may extend over more than one physical line.

2. More than one SAGEN statement may appear on one physical line.

3. SAGEN keywords and variables may appear in any column.

4. Ada comments may be embedded within a SAGEN statement.

3.3 Semantic Conventions

SAGEN semantic conventions are as follows:

1. Non-SAGEN code (i.e. Ada source and comments) should be valid Ada. If the code is not legal Ada, SAGEN will function properly, but the generated SADMT code will not compile.

2. The Ada source code appearing within SAGEN blocks should not violate the SADMT process model. The user-supplied Ada code should not include direct calls of other process tasks nor the abort statement.

3. The data type of a port is assumed to be declared in a user-supplied package having the same name as the data type followed by "_pkg". For example, the package Order_pkg will be made visible to the process that has a port of type Order.

4. A temporary file called temporary.sagen is created and deleted by SAGEN. This file may appear if SAGEN terminates abnormally.

5. Comments placed within the main SAGEN block will appear before the package specification in the generated SADMT code. Comments placed within Ada source code in any SAGEN block will appear in the generated SADMT code as entered.

6. Any non-SAGEN code placed between SAGEN blocks will appear at the top of the next generated SADMT file.

3.4 Programmatic Conventions

1. The maximum number of subprocesses per parent process is set at 1000. This limit can be raised by changing constant *max_array_bound* in the SAGEN source file.

2. Variable names are limited to 80 characters. This limit can be raised by changing constant *max_line_length* in the SAGEN source file.

3. The generated SADMT files will be 80 characters wide. This convention can be altered by changing constant *max_line_length* in the SAGEN source file.

4. One physical input line is limited to 256 characters. This limit can be raised by changing variable *line* in the SAGEN source file.

3.5 Keyword Order

Process, platform or technology module must appear as the first SAGEN statement of each specification. Subprocess, inport, outport, parameters, subdata and cone may follow in any order.

Process, platform or technology module and end must appear once for each specification. Subprocess, inport, outport, parameters, subdata and cone may each appear zero or more times.

One link or one task block should then follow the main specification. A link block should appear for a platform or a non-leaf process or technology module. A task block should appear for a leaf process or technology module.

4. SYNTAX

SDS and BM/C3 architectures are described in three parts:

1. Process hierarchy, ports and data types

2. Port linkages

3. Process semantics

4.1 Process Hierarchy, Ports and Data Types

The syntax of SAGEN statements for specifying process hierarchy, ports and data types is:

```
[<with_or_use>]
{ $process <name>  |  $platform <name> := <alias> |
 $tech[nology]_module <name> |
 $dynamic_tech[nology]_module <name> := <alias> }  is
   $subprocess[es] <name> [(<range>)] [:= (<param_list>)]
          {,<name> [(<range>)] [:= (<param_list>)] }* ;
   $[selectable_] [{ data_ | control_ | mech_ }] { inport[s] | outport[s] }
        <name> [(<range>)] : <data_type> [:= (<param_list>)]
      {, <name> [(<range>)] : <data_type> [:= (<param_list>)] }*;
   ${cone | event | platform}_inport [<name>];
   $parameter[s] <name> : <data_type> [(<discriminant>)] := (<default>)
          {,<name> : <data_type> [(<discriminant>)] := (<default>) }* ;
   $subdata <data_type> {, <data_type> }* ;
   $cone[s] <data_type> {, <data_type> }* ;
$begin
 [Ada source lines (body)]
$end;
```

4.2 Port Linkages

The syntax of SAGEN statements for specifying port linkages is:

```
[<with_or_use>]
$link[s] <name> is
```

```
[<declarations>]
$begin
 [Ada source lines (link)]
$end;
```

4.3 Process Semantics

The syntax of SAGEN statements for specifying process semantics is:

```
[<with_or_use>]
$task <name> is
 [<declarations>]
$begin
 [Ada source lines (task)]
$end;
```

5. SEMANTICS

5.1 Process Hierarchy, Ports and Data Types

The semantics of each SAGEN statement for specifying process hierarchy, ports and data types are described below.

```
[<with_or_use>]
```

These Ada context clauses (with) or visibility clauses (use) are placed at the head of the procedure specification.

```
{ $process <name>  |   $platform <name> := <alias>  |
 $tech[nology]_module <name> |
 $dynamic_tech[nology]_module <name> := <alias> }  is
```

Process, platform or technology module specifies the name of an SDI process, platform or technology module, respectively. In addition, a designator string name must be specified for a platform or a dynamic technology module. A dynamic technology module is a special module to facilitate the specification of companion modules such as sensor returns (see [Linn 88]). The specification and body of the creator task (which is what makes a platform process different from a regular SADMT process) is automatically inserted into the task body of the named platform.

```
$subprocess[es] <name> [(<range>)] [:= (<param_list>)]
        {,<name> [(<range>)] [:= (<param_list>)] }* ;
```

Subprocess specifies the names of the SDI subprocesses associated with the named process, platform or technology module. The range parameter is used to specify an array of subprocesses. The param_list parameter may be used to specify parameters for initializing the subprocess (see [Linn 88]). These parameters will be included in the call to procedure initialize for the subprocess. If the named process, platform or technology module has no subprocesses (i.e. it is a leaf), the subprocess statement must not appear.

$[selectable_] [{ data_ | control_ | mech_ }] { inport[s] | outport[s] }
    <name> [(<range>)] : <data_type> [:= (<param_list>)]
    {, <name> [(<range>)] : <data_type> [:= (<param_list>)] }*;

Inport specifies the names of ports that input data to the named process or technology module and the type of data flowing into each port. Outport specifies the names of ports that output data from the named process or technology module and the type of data flowing out of each port. (Platforms do not have ports. Dynamic technology modules have only special input ports (see below).) Ports may be further designated as selectable. A selectable port is one of a special subset of ports of the same type to which or from which data may be specifically directed (see [Linn 88]). Ports may also be designated as data, control or mechanism ports (a la the SDI System Design Language [SRS 87]). Such a designation is for documentation purposes only and does not influence the generated SADMT. The range parameter is used to specify an array of ports. The param_list parameter may be used to specify parameters for initializing the port (see [Linn 88]). These parameters will be included in the call to procedure initialize for the port.

${cone | event | platform}_inport [<name>];

Cone_inport, event_inport and platform_inport specify special input ports for dynamic technology modules. These are the only types of ports allowed for dynamic technology modules (see [Linn 88]). The name parameter specifies a name for the port. If a name is not provided, a default name will be supplied - "cone_in" for cone_inport, "event_in" for event_inport, and "platform_in" for platform_inport.

$parameter[s] <name> : <data_type> [(<discriminant>)] := (<default>)
    {,<name> : <data_type> [(<discriminant>)] := (<default>) }* ;

Parameter specifies a set of parameters that are supplied to the initialize procedure in the named process, platform or technology module. Data type specifies the data type of the named parameter and default specifies its default value. A discriminant may be supplied for the data type.

$subdata <data_type> {, <data_type> }* ;

Subdata specifies the types of data that flow within and between the subprocesses of the named process, platform or technology module. These data types are made visible to the package specification of the named process, platform or technology module. A data type that is already specified for a port at this level need not be respecified as subdata for its subprocesses. If the named process, platform or technology module has no subprocesses, the subdata statement must not appear.

$cone[s] <data_type> {, <data_type> }* ;

Cone specifies data types for cones. Cones only make sense for leaf technology modules. A warning will be generated by SAGEN if cones are specified for processes or platforms or nonleaf technology modules. The cone data types are made visible to the package specification of the named technology module. Furthermore, procedure create_cone is renamed in the task body.

$begin

Begin specifies the beginning of a block of Ada source code.

[Ada source lines (body)]

These Ada source lines are procedures which are placed in the package body to be referenced by the initialize procedure or the task associated with the named process, platform or technology module.

$end;

End specifies the end of the process, platform or technology module block.

5.2 Port Linkages

The semantics of each SAGEN statement for specifying port linkages is described below.

[<with_or_use>]

These Ada context clauses (with) or visibility clauses (use) are placed at the head of the initialize procedure.

$link[s] <name> is

Link indicates the start of a block of Ada source lines that perform the necessary linkages among the subprocesses of the named process, platform or technology module. The name parameter must correspond to the name of the previous process, platform or technology module block. The link block must not be specified for a leaf process or technology module.

[<declarations>]

These Ada declarations are placed in the declarative region of the initialize procedure.

$begin

Begin specifies the beginning of a block of Ada source code.

[Ada source lines (link)]

These Ada source lines specify the linkages among the subprocesses of the named process, platform or technology module.

$end;

End specifies the end of the linkage block.

5.3 Process Semantics

The semantics of each SAGEN statement for specifying process semantics is described below.

[<with_or_use>]

These Ada context clauses (with) or visibility clauses (use) are placed at the head of the task body.

> $task <name> is

Task indicates the start of a block of Ada source lines that supply the semantics of the named process or technology module. The name parameter must correspond to the name of the previous process or technology module block. The task block must not be specified for a platform or a non-leaf process or technology module.

> [<declarations>]

These Ada declarations are placed in the declarative region of the task body.

> $begin

Begin specifies the beginning of a block of Ada source code.

> [Ada source lines (task)]

These Ada source lines specify the semantics of the named process or technology module.

> $end;

End specifies the end of the task block.

6. EXECUTION

SAGEN is invoked at the user's terminal by typing:

> sagen

The following prompt will then appear on the screen:

> Please enter the name of the SAGEN file

The user should then enter the name of the file containing the code to be translated.

If any lexical or syntactic errors are detected by SAGEN, an error message will appear on the screen. The message will indicate the type of error and display the line on which the error occurred.

After translation is complete, several new files are created that contain the generated SADMT code. The names of the new files will be:

<name>.a	for package specifications
<name>_body.a	for package bodies
<name>_link.a	for port linkages
<name>_task.a	for process semantics

where <name> is the name of the associated process, platform, or technology module.

7. REFERENCES

[Bell 71]   Bell, C. Gordon and Allen Newell, *Computer Structures: Readings and Examples* , McGraw-Hill, 1971.

[Cohen 88]   Cohen, Howard, Steve H. Edwards, Cathy Jo Linn, Joseph L. Linn, and Cy D. Ardoin, *A Simple Example of an SADMT Architecture Specification* ,Institute for Defense Analyses, 1988.

[Linn 88]   Linn, Joseph L., Cathy Jo Linn, Stephen H. Edwards, Michael R. Kappel, Cy D. Ardoin and John Salasin, *Strategic Defense Initiative Architecture Dataflow Modeling Technique* , Version 1.50, IDA Paper P-2035, Institute for Defense Analyses, March 1988.

[SRS 87]   *SDI-SDL Description Example for Version 1.2, SRS Technologies*, October 1987.

APPENDIX A - SAGEN EXAMPLE

An example system specification in SAGEN is given in this Appendix, followed by the SADMT generated by the SAGEN processor in Appendix B, and the output generated by the Simulation Framework in Appendix C. An example of a simple SDI architecture specified in SAGEN, along with the automatically generated SADMT and the simulation output is given in [Cohen 88].

The example network of processes is shown in Figures 4 and 5.
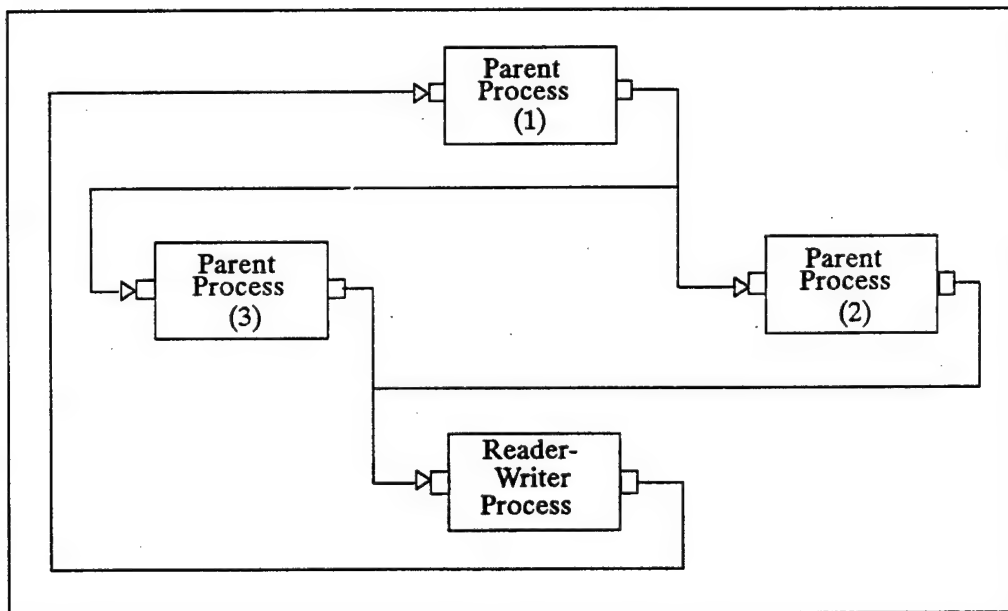
Figure 4. Top Level Platform
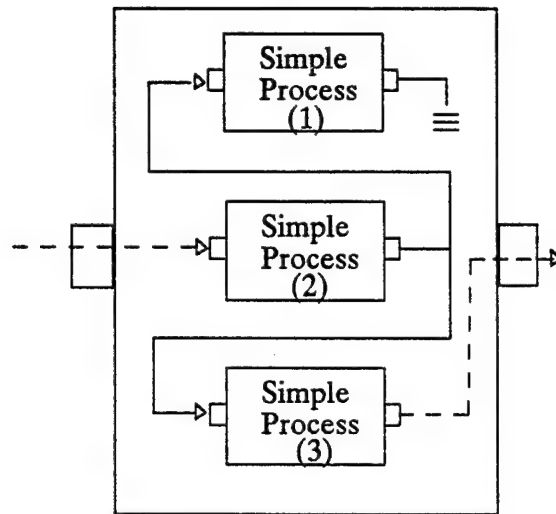
Figure 5. Exploded View of Parent Process

The following SAGEN represents the system of processes shown in these figures:

——————————————————————————
————————————— Top Level Platform —————————————
——————————————————————————

```
$platform TopLevel_Platform:=TOPLEVEL is
  $subprocesses Parent_Process(1..3), RW_Process;
  $subdata Simple_Msg;
$end;

$links TopLevel_Platform is
$begin
  internal_link (Z.SUB.Parent_Process(1).message_out,
          Z.SUB.Parent_Process(2).message_in);
  internal_link (Z.SUB.Parent_Process(1).message_out,
          Z.SUB.Parent_Process(3).message_in);
  internal_link (Z.SUB.Parent_Process(2).message_out,
```

```
          Z.SUB.RW_Process.message_in);
   internal_link (Z.SUB.Parent_Process(3).message_out,
          Z.SUB.RW_Process.message_in);
   internal_link (Z.SUB.RW_Process.message_out,
          Z.SUB.Parent_Process(1).message_in);
$end;
```

———————————————— Parent Process ————————————————

```
$process Parent_Process is
  $subprocesses Simple_Process(1..3):=(wt(i));
  $inport  message_in :Simple_Msg;
  $outport message_out:Simple_Msg;
$end;
```

```
$links Parent_Process is
  wt: constant array(1..3) of PDL_time_type := (20,30,50);
$begin
  internal_link  (Z.SUB.Simple_Process(2).message_out,
          Z.SUB.Simple_Process(1).message_in);
  internal_link  (Z.SUB.Simple_Process(2).message_out,
          Z.SUB.Simple_Process(3).message_in);
  inherited_link (Z.message_in,
          Z.SUB.Simple_Process(2).message_in);
  inherited_link (Z.SUB.Simple_Process(3).message_out,
          Z.message_out);
$end;
```

———————————————— Simple Subprocess ————————————————

```
$process Simple_Process is
  $inport  message_in :Simple_Msg;
  $outport message_out:Simple_Msg;
  $parameter waittime:PDL_time_type:=(20);
$end;
```

```
$task Simple_Process is
  buffer: Simple_msg;
$begin
  loop
    wait_for_activity(Z.PDL);
    buffer:= port_data(Z.message_in);
    consume(Z.message_in);
    wait(Z.PDL,Z.PRM.waittime);
    buffer.last_slot:= buffer.last_slot + 1;
    buffer.route(buffer.last_slot):= integer(Z.PDL.process_id);
```

```
      emit(Z.message_out,buffer);
   end loop;
exception
  when others =>
    write_process_id(Z.PDL,"AND THEN SOME EXCEPTION in simple_proc, ");
$end;
```

――――――――――――――――――――――――――
――――――――――――― RW Subprocess ―――――――――――
――――――――――――――――――――――――――

```
$process RW_Process is
  $inport  message_in :Simple_Msg;
  $outport message_out:Simple_Msg;
$end;

$task RW_Process is
  buffer               : Simple_Msg;
  start_up_time, last_time  : PDL_time_type   := 1000;
  which_port           : integer     := -50;
$begin
  start_up_time := Current_PDL_time;
  loop
    while not port_empty(Z.message_in) loop
      write_process_id(Z.PDL,"    DEQUEUING--","|",false);
      put_msg(port_data(Z.message_in),0);
      consume(Z.message_in);
    end loop;
    if last_time /= Current_PDL_time then
      if (Current_PDL_time - start_up_time) mod 40 = 0
         or (Current_PDL_time - start_up_time) mod 40 = 30 then
        buffer.time_created := Current_PDL_time;
        buffer.last_slot := 0;
           emit(Z.message_out,buffer);
        last_time := Current_PDL_time;
      end if;
    end if;
    wait_for_activity(Z.PDL,(Z.message_out.PORT
                  ,Z.message_out.PORT
                  ,Z.message_out.PORT
                  ,Z.message_out.PORT
                  ,Z.message_out.PORT
                  ,Z.message_out.PORT
                  ,Z.message_out.PORT
                  ,Z.message_in.PORT)
                  ,which_port
                  ,Time_out => 10);
  end loop;
```

```
exception
  when others =>
    put_line("AND THEN SOME EXCEPTION in rw_proc");
$end;
```

APPENDIX B - GENERATED SADMT

The following SADMT output files are created by the SAGEN tool:

****************************** TopLevel_Platform.a ******************************

————————————————————————————

———————————— Top Level Platform ————————————

————————————————————————————

```
with Cones_n_Platforms,Parent_Process_pkg,RW_Process_pkg,Simple_Msg_pkg;
package TopLevel_Platform_pkg is
  use Cones_n_Platforms;
  use PDL_pkg,Simple_Msg_pkg;
  TopLevel_Platform_designator    : constant platform_designator_type
    := new string'("TOPLEVEL");
  TopLevel_Platform_name          : PDL_string_ptr := new string'
    ("TopLevel_Platform");
  TopLevel_Platform_discr_name    : PDL_string_ptr := empty_string;
  TopLevel_Platform_characteristic : PDL_string_ptr := new string'
    ("typename=TopLevel_Platform");
  type TopLevel_Platform_subprocesses is private;

  package TopLevel_Platform_PARAM_pkg is
    type TopLevel_Platform_parameterization is record
      null;
    end record;

    type TopLevel_Platform_parameterization_ptr is access
      TopLevel_Platform_parameterization;
  end TopLevel_Platform_PARAM_pkg;
  use TopLevel_Platform_PARAM_pkg;

  package TopLevel_Platform_CP_pkg is new interface_procs.PlatformDefiner_pkg
    (T=>TopLevel_Platform_parameterization,
     T_ptr=>TopLevel_Platform_parameterization_ptr);
private
  use PIG_pkg,Parent_Process_pkg,RW_Process_pkg;
  type Parent_Process_vector is array(integer range <>) of
    Parent_Process_type;
  type TopLevel_Platform_subprocesses is record
    PIG: PIG_type;
    Parent_Process: Parent_Process_vector(1..3);
    RW_Process: RW_Process_type;
  end record;
end TopLevel_Platform_pkg;
```

```
****************************** TopLevel_Platform_body.a ******************************
package body TopLevel_Platform_pkg is
  use Simple_Msg_pkg.PD.Procedures;
  use PDL_IO; use TXT_IO, INT_IO, TIME_IO, DURATION_IO;
  use interface_procs;

  type TopLevel_Platform_block;
  type TopLevel_Platform_type is access TopLevel_Platform_block;

  type TopLevel_Platform_block is record
    PDL: PDL_ptr := new_PDL_block(platform);
    SUB: TopLevel_Platform_subprocesses;
  end record;

  procedure initialize (ZZ: out PIG_type; param:
    TopLevel_Platform_parameterization_ptr; my_name: PDL_string_ptr :=
    TopLevel_Platform_name; discr_name: PDL_string_ptr :=
    TopLevel_Platform_discr_name; characteristic: PDL_string_ptr :=
    TopLevel_Platform_characteristic) is separate;

  package Creator is new PlatformCreator_pkg (
    TopLevel_Platform_parameterization,
    TopLevel_Platform_parameterization_ptr, lookup_platform_designator
    (TopLevel_Platform_designator), initialize);
end TopLevel_Platform_pkg;

****************************** TopLevel_Platform_link.a ******************************

separate (TopLevel_Platform_pkg)
procedure initialize (ZZ: out PIG_type; param:
  TopLevel_Platform_parameterization_ptr; my_name: PDL_string_ptr :=
  TopLevel_Platform_name; discr_name: PDL_string_ptr :=
  TopLevel_Platform_discr_name; characteristic: PDL_string_ptr :=
  TopLevel_Platform_characteristic) is
  Z: TopLevel_Platform_type;

begin
  Z := new TopLevel_Platform_block;
  declare
    PIG : PIG_type renames Z.SUB.PIG;
    Parent_Process : Parent_Process_vector renames Z.SUB.Parent_Process;
    RW_Process : RW_Process_type renames Z.SUB.RW_Process;
    MYSELF : PDL_ptr renames Z.PDL;
  begin
    set_process_parent(MYSELF,null,my_name,discr_name,characteristic);
    if init_debug_level > 100 then
```

```
        write_process_full(MYSELF,"*init> "," before start_up");
      end if;
      initialize(PIG,MYSELF);
      for i in 1..3 loop
        initialize(Parent_Process(i),MYSELF
          ,discr_name => new string'(integer'IMAGE(i)));
      end loop;
      initialize(RW_Process,MYSELF);
      ZZ := PIG;

    internal_link (Z.SUB.Parent_Process(1).message_out,
            Z.SUB.Parent_Process(2).message_in);
    internal_link (Z.SUB.Parent_Process(1).message_out,
            Z.SUB.Parent_Process(3).message_in);
    internal_link (Z.SUB.Parent_Process(2).message_out,
            Z.SUB.RW_Process.message_in);
    internal_link (Z.SUB.Parent_Process(3).message_out,
            Z.SUB.RW_Process.message_in);
    internal_link (Z.SUB.RW_Process.message_out,
            Z.SUB.Parent_Process(1).message_in);
    end;

    if init_debug_level > 100 then
      write_process_full(Z.PDL,"*init> "," after start_up");
    end if;
    exception
      when others => write_process_full(Z.PDL,"***Some error in ","**");
  end initialize;
```

***************************** Parent_Process.a *****************************

——
————————————————— Parent Process ——————————————
——

```
with PDL_pkg,Simple_Msg_pkg,Simple_Process_pkg;
package Parent_Process_pkg is
  use PDL_pkg,Simple_Msg_pkg;

  type Parent_Process_block;
  type Parent_Process_type is access Parent_Process_block;

  type Parent_Process_subprocesses is private;

  type Parent_Process_block is record
    PDL: PDL_ptr := new_PDL_block(nonleaf);
```

```
    SUB: Parent_Process_subprocesses;
    message_in: Simple_Msg_ipptr := new Simple_Msg_port(inport);
    message_out: Simple_Msg_opptr := new Simple_Msg_port(outport);
  end record;


  Parent_Process_name         : PDL_string_ptr := new string'
    ("Parent_Process");
  Parent_Process_type_name    : PDL_string_ptr := new string'
    ("Parent_Process");
  Parent_Process_discr_name   : PDL_string_ptr := empty_string;
  Parent_Process_characteristic : PDL_string_ptr := new string'   ·
    ("typename=Parent_Process");


  procedure initialize (Z: in out Parent_Process_type; Parent: PDL_ptr;
    my_name: PDL_string_ptr := Parent_Process_name;
    discr_name: PDL_string_ptr := Parent_Process_discr_name;
    type_name: PDL_string_ptr := Parent_Process_type_name;
    characteristic: PDL_string_ptr := Parent_Process_characteristic);

private
  use Simple_Process_pkg;
  type Simple_Process_vector is array(integer range <>) of
    Simple_Process_type;
  type Parent_Process_subprocesses is record
    Simple_Process: Simple_Process_vector(1..3);
  end record;
end Parent_Process_pkg;


***************************** Parent_Process_body.a *****************************
package body Parent_Process_pkg is
  use PDL_IO; use TXT_IO, INT_IO, TIME_IO, DURATION_IO;
  use Simple_Msg_pkg.PD.Procedures;
  procedure initialize (Z: in out Parent_Process_type; Parent: PDL_ptr;
    my_name: PDL_string_ptr := Parent_Process_name;
    discr_name: PDL_string_ptr := Parent_Process_discr_name;
    type_name: PDL_string_ptr := Parent_Process_type_name;
    characteristic: PDL_string_ptr := Parent_Process_characteristic
    ) is separate;
end Parent_Process_pkg;


**************************** Parent_Process_link.a *****************************

separate (Parent_Process_pkg)
procedure initialize (Z: in out Parent_Process_type; Parent: PDL_ptr;
  my_name: PDL_string_ptr := Parent_Process_name;
  discr_name: PDL_string_ptr := Parent_Process_discr_name;
```

```
    type_name: PDL_string_ptr := Parent_Process_type_name;
    characteristic: PDL_string_ptr := Parent_Process_characteristic) is

  wt: constant array(1..3) of PDL_time_type := (20,30,50);
begin
  Z := new Parent_Process_block;
  declare
    message_in : Simple_Msg_ipptr renames Z.message_in;
    message_out : Simple_Msg_opptr renames Z.message_out;
    Simple_Process : Simple_Process_vector renames Z.SUB.Simple_Process;
    MYSELF : PDL_ptr renames Z.PDL;
  begin
    set_process_parent(MYSELF,Parent,my_name,discr_name,characteristic);
    if init_debug_level > 130 then
      write_process_full(MYSELF,"*init> "," before start_up");
    end if;
    initialize(message_in,MYSELF,"portname=message_in","message_in");
    initialize(message_out,MYSELF,"portname=message_out","message_out");
    for i in 1..3 loop
      initialize(Simple_Process(i),MYSELF,wt(i)
        ,discr_name => new string'(integer'IMAGE(i)));
    end loop;

  internal_link  (Z.SUB.Simple_Process(2).message_out,
          Z.SUB.Simple_Process(1).message_in);
  internal_link  (Z.SUB.Simple_Process(2).message_out,
          Z.SUB.Simple_Process(3).message_in);
  inherited_link (Z.message_in,
          Z.SUB.Simple_Process(2).message_in);
  inherited_link (Z.SUB.Simple_Process(3).message_out,
          Z.message_out);
  end;
  make_known(Z.PDL);

  if init_debug_level > 130 then
    write_process_full(Z.PDL,"*init> "," after start_up");
  end if;
  exception
    when others => write_process_full(Z.PDL,"***Some error in ","**");
end initialize;
```

***************************** Simple_Process.a *****************************

------------------------ Simple Subprocess ---------------------

----

```
with PDL_pkg,Simple_Msg_pkg;
package Simple_Process_pkg is
  use PDL_pkg,Simple_Msg_pkg;

  package Simple_Process_PARAM_pkg is
    type Simple_Process_parameterization is record
      waittime: PDL_time_type := 20;
    end record;
  end Simple_Process_PARAM_pkg;
  use Simple_Process_PARAM_pkg;

  type Simple_Process_block;
  type Simple_Process_type is access Simple_Process_block;

  task type Simple_Process_task is
    entry start_up(Z:Simple_Process_type);
  end Simple_Process_task;
  type Simple_Process_task_ptr is access Simple_Process_task;

  type Simple_Process_block is record
    PDL: PDL_ptr := new_PDL_block(leaf);
    SEM: Simple_Process_task_ptr;
    PRM: Simple_Process_parameterization;
    message_in: Simple_Msg_ipptr := new Simple_Msg_port(inport);
    message_out: Simple_Msg_opptr := new Simple_Msg_port(outport);
  end record;

  Simple_Process_name          : PDL_string_ptr := new string'
    ("Simple_Process");
  Simple_Process_type_name     : PDL_string_ptr := new string'
    ("Simple_Process");
  Simple_Process_discr_name    : PDL_string_ptr := empty_string;
  Simple_Process_characteristic : PDL_string_ptr := new string'
    ("typename=Simple_Process");

  procedure initialize (Z: in out Simple_Process_type; Parent: PDL_ptr;
    waittime_param : PDL_time_type := 20; my_name: PDL_string_ptr :=
    Simple_Process_name; discr_name: PDL_string_ptr :=
    Simple_Process_discr_name; type_name: PDL_string_ptr :=
    Simple_Process_type_name; characteristic: PDL_string_ptr :=
    Simple_Process_characteristic);
end Simple_Process_pkg;
```

***************************** Simple_Process_body.a *****************************
```
package body Simple_Process_pkg is
  use PDL_IO; use TXT_IO, INT_IO, TIME_IO, DURATION_IO;
```

```
      use Simple_Msg_pkg.PD.Procedures;
      task body Simple_Process_task is separate;
      procedure initialize (Z: in out Simple_Process_type; Parent: PDL_ptr;
        waittime_param : PDL_time_type := 20; my_name: PDL_string_ptr :=
        Simple_Process_name; discr_name: PDL_string_ptr :=
        Simple_Process_discr_name; type_name: PDL_string_ptr :=
        Simple_Process_type_name; characteristic: PDL_string_ptr :=
        Simple_Process_characteristic) is separate;
end Simple_Process_pkg;

***************************** Simple_Process_link.a *****************************
separate (Simple_Process_pkg)
procedure initialize (Z: in out Simple_Process_type; Parent: PDL_ptr;
   waittime_param : PDL_time_type := 20; my_name: PDL_string_ptr :=
   Simple_Process_name; discr_name: PDL_string_ptr :=
   Simple_Process_discr_name; type_name: PDL_string_ptr :=
   Simple_Process_type_name; characteristic: PDL_string_ptr :=
   Simple_Process_characteristic) is
begin
  Z := new Simple_Process_block;
  declare
    message_in : Simple_Msg_ipptr renames Z.message_in;
    message_out : Simple_Msg_opptr renames Z.message_out;
    waittime : PDL_time_type renames Z.PRM.waittime;
    MYSELF : PDL_ptr renames Z.PDL;
  begin
    set_process_parent(MYSELF,Parent,my_name,discr_name,characteristic);
    if init_debug_level > 130 then
      write_process_full(MYSELF,"*init> "," before start_up");
    end if;
    waittime := waittime_param;
    initialize(message_in,MYSELF,"portname=message_in","message_in");
    initialize(message_out,MYSELF,"portname=message_out","message_out");
  end;
  Z.SEM := new Simple_Process_task;
  Z.SEM.start_up(Z);

  if init_debug_level > 130 then
    write_process_full(Z.PDL,"*init> "," after start_up");
  end if;
  exception
    when others => write_process_full(Z.PDL,"***Some error in ","**");
end initialize;

***************************** Simple_Process_task.a *****************************
```

```
separate (Simple_Process_pkg)
task body Simple_Process_task is
  use timing_ops;
  Z : Simple_Process_type := null;

  buffer: Simple_msg;
begin
  accept start_up(Z:Simple_Process_type) do
    Simple_Process_task.Z := Z;
    make_known(Z.PDL);
  end start_up;

  declare
    message_in : Simple_Msg_ipptr renames Z.message_in;
    message_out : Simple_Msg_opptr renames Z.message_out;
    waittime : PDL_time_type renames Z.PRM.waittime;
    MYSELF : PDL_ptr renames Z.PDL;
    package WAITING_pkg is new Wait_pkg(MYSELF);
    use WAITING_pkg;
  begin
    wait_for_initialization;
  loop
    wait_for_activity(Z.PDL);
    buffer:= port_data(Z.message_in);
    consume(Z.message_in);
    wait(Z.PDL,Z.PRM.waittime);
    buffer.last_slot:= buffer.last_slot + 1;
    buffer.route(buffer.last_slot):= integer(Z.PDL.process_id);
    emit(Z.message_out,buffer);
  end loop;
exception
  when others =>
    write_process_id(Z.PDL,"AND THEN SOME EXCEPTION in simple_proc, ");
  end;
  write_process_full(Z.PDL,"************************ Invalid SADMT Process");
  kill_process(Z.PDL);
end Simple_Process_task;
```

***************************** RW_Process.a *****************************

———————————————————————————————————
——————————— RW Subprocess ———————————
———————————————————————————————————

```
with PDL_pkg,Simple_Msg_pkg;
package RW_Process_pkg is
```

```
use PDL_pkg,Simple_Msg_pkg;

type RW_Process_block;
type RW_Process_type is access RW_Process_block;

task type RW_Process_task is
  entry start_up(Z:RW_Process_type);
end RW_Process_task;
type RW_Process_task_ptr is access RW_Process_task;

type RW_Process_block is record
  PDL: PDL_ptr := new_PDL_block(leaf);
  SEM: RW_Process_task_ptr;
  message_in: Simple_Msg_ipptr := new Simple_Msg_port(inport);
  message_out: Simple_Msg_opptr := new Simple_Msg_port(outport);
end record;

RW_Process_name         : PDL_string_ptr := new string'("RW_Process");
RW_Process_type_name    : PDL_string_ptr := new string'("RW_Process");
RW_Process_discr_name   : PDL_string_ptr := empty_string;
RW_Process_characteristic : PDL_string_ptr := new string'
  ("typename=RW_Process");

procedure initialize (Z: in out RW_Process_type; Parent: PDL_ptr;
  my_name: PDL_string_ptr := RW_Process_name;
  discr_name: PDL_string_ptr := RW_Process_discr_name;
  type_name: PDL_string_ptr := RW_Process_type_name;
  characteristic: PDL_string_ptr := RW_Process_characteristic);
end RW_Process_pkg;
```

***************************** RW_Process_body.a *****************************
```
package body RW_Process_pkg is
  use PDL_IO; use TXT_IO, INT_IO, TIME_IO, DURATION_IO;
  use Simple_Msg_pkg.PD.Procedures;
  task body RW_Process_task is separate;
  procedure initialize (Z: in out RW_Process_type; Parent: PDL_ptr;
    my_name: PDL_string_ptr := RW_Process_name;
    discr_name: PDL_string_ptr := RW_Process_discr_name;
    type_name: PDL_string_ptr := RW_Process_type_name;
    characteristic: PDL_string_ptr := RW_Process_characteristic
    ) is separate;
end RW_Process_pkg;
```

***************************** RW_Process_link.a *****************************
```
separate (RW_Process_pkg)
procedure initialize (Z: in out RW_Process_type; Parent: PDL_ptr;
```

```
   my_name: PDL_string_ptr := RW_Process_name; discr_name: PDL_string_ptr :=
   RW_Process_discr_name; type_name: PDL_string_ptr := RW_Process_type_name;
   characteristic: PDL_string_ptr := RW_Process_characteristic) is
begin
 Z := new RW_Process_block;
 declare
   message_in : Simple_Msg_ipptr renames Z.message_in;
   message_out : Simple_Msg_opptr renames Z.message_out;
   MYSELF : PDL_ptr renames Z.PDL;
 begin
   set_process_parent(MYSELF,Parent,my_name,discr_name,characteristic);
   if init_debug_level > 130 then
     write_process_full(MYSELF,"*init> "," before start_up");
   end if;
   initialize(message_in,MYSELF,"portname=message_in","message_in");
   initialize(message_out,MYSELF,"portname=message_out","message_out");
 end;
 Z.SEM := new RW_Process_task;
 Z.SEM.start_up(Z);

 if init_debug_level > 130 then
   write_process_full(Z.PDL,"*init> "," after start_up");
 end if;
 exception
   when others => write_process_full(Z.PDL,"***Some error in ","**");
end initialize;
```

**************************** RW_Process_task.a ****************************

```
separate (RW_Process_pkg)
task body RW_Process_task is
 use timing_ops;
 Z : RW_Process_type := null;

 buffer              : Simple_Msg;
 start_up_time, last_time  : PDL_time_type   := 1000;
 which_port              : integer         := -50;
begin
 accept start_up(Z:RW_Process_type) do
   RW_Process_task.Z := Z;
   make_known(Z.PDL);
 end start_up;

 declare
   message_in : Simple_Msg_ipptr renames Z.message_in;
   message_out : Simple_Msg_opptr renames Z.message_out;
```

```
    MYSELF : PDL_ptr renames Z.PDL;
    package WAITING_pkg is new Wait_pkg(MYSELF);
    use WAITING_pkg;
  begin
    wait_for_initialization;
  start_up_time := Current_PDL_time;
  loop
    while not port_empty(Z.message_in) loop
      write_process_id(Z.PDL,"    DEQUEUING-","|",false);
      put_msg(port_data(Z.message_in),0);
      consume(Z.message_in);
    end loop;
    if last_time /= Current_PDL_time then
      if (Current_PDL_time - start_up_time) mod 40 = 0
          or (Current_PDL_time - start_up_time) mod 40 = 30 then
        buffer.time_created := Current_PDL_time;
        buffer.last_slot := 0;
            emit(Z.message_out,buffer);
        last_time := Current_PDL_time;
      end if;
    end if;
    wait_for_activity(Z.PDL,(Z.message_out.PORT
                    ,Z.message_out.PORT
                    ,Z.message_out.PORT
                    ,Z.message_out.PORT
                    ,Z.message_out.PORT
                    ,Z.message_out.PORT
                    ,Z.message_out.PORT
                    ,Z.message_in.PORT)
                    ,which_port
                    ,Time_out => 10);
  end loop;
exception
  when others =>
    put_line("AND THEN SOME EXCEPTION in rw_proc");
  end;
  write_process_full(Z.PDL,"************************* Invalid SADMT Process");
  kill_process(Z.PDL);
end RW_Process_task;
```

APPENDIX C - SIMULATION OUTPUT

The following is the output generated by running the SADMT description of the system of processes depicted in Figures 4 and 5 on the prototype SSF simulation facility:

hello
simulation begins..........
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=160>|the message ts,r=0:2:3:5:6:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=160>|the message ts,r=0:2:3:8:9:
　　　　DEQUEUING--RW_Process/[PL]PR=[2]21<t=185>|the message ts,r=25:13:14:16:17:
　　　　DEQUEUING--RW_Process/[PL]PR=[2]21<t=185>|the message ts,r=25:13:14:19:20:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=230>|the message ts,r=30:2:3:5:6:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=230>|the message ts,r=30:2:3:8:9:
AND THEN SOME EXCEPTION in Simple_Process(1)/[PL]PR=[2]12|@|Parent_Process/[PL]PR=[2]-4|on|
AND THEN SOME EXCEPTION in Simple_Process(2)/[PL]PR=[2]13|@|Parent_Process/[PL]PR=[2]-4|on|
AND THEN SOME EXCEPTION in Simple_Process(3)/[PL]PR=[2]14|@|Parent_Process/[PL]PR=[2]-4|on|
AND THEN SOME EXCEPTION in Simple_Process(1)/[PL]PR=[2]15|@|Parent_Process/[PL]PR=[2]-5|on|
AND THEN SOME EXCEPTION in Simple_Process(2)/[PL]PR=[2]16|@|Parent_Process/[PL]PR=[2]-5|on|
AND THEN SOME EXCEPTION in Simple_Process(3)/[PL]PR=[2]17|@|Parent_Process/[PL]PR=[2]-5|on|
AND THEN SOME EXCEPTION in Simple_Process(1)/[PL]PR=[2]18|@|Parent_Process/[PL]PR=[2]-6|on|
AND THEN SOME EXCEPTION in Simple_Process(2)/[PL]PR=[2]19|@|Parent_Process/[PL]PR=[2]-6|on|
AND THEN SOME EXCEPTION in Simple_Process(3)/[PL]PR=[2]20|@|Parent_Process/[PL]PR=[2]-6|on|
AND THEN SOME EXCEPTION in RW_Process/[PL]PR=[2]21|@|TopLevel_Platform(2)/[PL]PR=[2]0<t=
AND THEN SOME EXCEPTION in gyro, Gyro_Process/[PL]PR=[2]22<t=260>
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=310>|the message ts,r=40:2:3:5:6:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=310>|the message ts,r=40:2:3:8:9:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=390>|the message ts,r=70:2:3:5:6:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=390>|the message ts,r=70:2:3:8:9:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=470>|the message ts,r=80:2:3:5:6:
　　　　DEQUEUING--RW_Process/[PL]PR=[1]10<t=470>|the message ts,r=80:2:3:8:9:

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